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ABSTRACT

Two experiments examined the effect of haptic exploration on visual recognition of nonsense forms by 4- to 7-year-old children. In Experiment 1, haptic activity was optional for S. The amount and type of activity was rated. Those Ss who voluntarily produced haptic activity reached criterion in a repeated exposure-test recognition task in fewer trials than Ss who produced no activity. There was a tendency for the effect of haptic activity to decrease with age. In Experiment 2, 4-year olds were trained in haptic exploration and then assigned to predetermined experimental conditions defined by the presence or absence of haptic activity. Again, visual recognition was enhanced by haptic exploration. These experiments are compared with previous studies which failed to demonstrate haptic facilitation of visual recognition, and possible explanations for haptic facilitation are discussed. (Author)

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THE ROLE OF STIMULUS-CORRELATED ACTIVITY IN CHILDREN'S PERCEPTION

by Peter Wolff

Report from the
Active Manipulation and Perceptual-Cognitive
Processes Element of Program 1

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Statement of Focus

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This technical report is from the Project on Variables and Processes in Cognitive Learning in Program 1, Conditions and Processes of Learning. General objectives of the program are to generate knowledge and develop general taxonomies, models, or theories of cognitive learning, and to utilize the knowledge in the development of curriculum materials and procedures. Contributing to these program objectives, this project has these objectives: to ascertain the important variables in cognitive learning and to apply relevant knowledge to the development of instructional materials and to the programming of instruction for individual students; to clarify the basic processes and abilities involved in concept learning; and to develop a system of individually guided motivation for use in the elementary school.

Acknowledgments

Special credit is due to John Hagen, John Gyr, William Uttal, and Dan Weintraub for their substantive contributions to this research. Experiment 1 is part of a Ph.D. thesis submitted to the University of Michigan. Experiment 2 was supported by the Wisconsin Research and Development Center for Cognitive Learning.

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Abstract

Two experiments examined the effect of haptic exploration on visual recognition of nonsense forms by 4- to 7-year-old children. In Experiment 1, haptic activity was optional for S. The amount and type of activity was rated. Those Ss who voluntarily produced haptic activity reached criterion in a repeated exposure-test recognition task in fewer trials than Ss who produced no activity. There was a tendency for the effect of haptic activity to decrease with age.

In Experiment 2, 4-year olds were trained in haptic exploration and then assigned to predetermined experimental conditions defined by the presence or absence of haptic activity. Again, visual recognition was enhanced by haptic exploration. These experiments are compared with previous studies which failed to demonstrate haptic facilitation of visual recognition, and possible explanations for haptic facilitation are discussed.

I
Introduction

Both Soviet and Piagetian developmental theories claim a central role for motor activity in children's perception. In the Russian system, reviewed by Pick (1964) and Zaporozhets (1965), perception in all modalities involves a copying of the external world by the perceiving organism. The percept itself is a composite of the feedback stimulation from this mirroring or copying process. Russian theorists have further hypothesized that for the young child, tactual-kinesthetic information is more basic to perception than visual information. While Piaget does not specify the mechanism by which activity contributes to perception, he has claimed that perception involves motor imitation, and that re-creation of the original percept through mental imagery depends on "deferred imitation" (Piaget, 1951; Piaget & Inhelder, 1956).

Consistent with these theories, young children have been observed to produce haptic manipulative activity during perceptual tasks (Zaporozhets, 1965), and bodily motor imitative movements to both animate and inanimate stimuli (Bandura & Walters, 1963; Guillaume, 1971; Piaget, 1951). Also, motoric involvement has been incorporated into various instructional techniques for inducing perceptual learning in children (Montessori, 1964).

However, as argued by Pick, Pick and Klein (1967), at no stage of development does tactual or haptic exploration lead to better perceptual performance than visual examination. Also, when a conflict between the two modalities is created, information from the visual modality remains dominant in the child's perceptual judgments.

It may be that haptic exploration is important in early perception, not as a modality in its own right, but for its contribution to visual perception. In one condition of a study by Chzhi-Tsin, Zinchenko, and Ruzskaya (1961), for example, Ss were trained to follow ocularly the movement of their hands while they were tracing a to-be-recognized test figure. While some facilitation resulted from this operation compared to a condition in which S visually tracked a pointer moving around the perimeter of the figure, the lack of statistical analysis leaves the reliability of this finding in doubt.

Using kindergarten, first, second, and third grade children, Butter and Zung (1970) failed to find any enhancement of visual recognition performance from accompanying haptic activity. More recently, negative results for haptic facilitation have been reported for preschool children by DeLeon, Raskin, and Gruen (1970) and Millar (1971).

In one study using a delayed recognition task, Denner and Cashdan (1967) tested preschool children's ability to recognize a two-dimensional hexagon after two days with three conditions of examination—visual only, visual and haptic, and visual and tactual contact with the stimulus encased in a clear plastic ball. Recognition performance was facilitated in the latter two conditions, which did not themselves differ. The authors concluded that the facilitative effect was due to S's activity orientation to the object, rather than to specific information from a haptic modality.

Thus, while observational studies suggest that young children commonly exhibit haptic activity, there is little empirical support for the centrality of haptic exploration either as a modality in its own right, or as an adjunct to visual perception. One major problem in the studies cited above is that they contain no evidence that children in a natural situation would use haptic exploration with the particular stimulus materials and in the particular perceptual tasks used in these studies. In the first experiment of the present study, a more direct assessment of the role of overt activity in children's perception was made by combining observational and experimental methods in the same procedure. Children from 4 to 7 years of age were tested in a structured perceptual task in which haptic manipulation was available, but not required. We could then determine both the extent of haptic involvement with the stimulus material and its effect on performance in a perceptual recognition task.

II
Experiment 1

Method

Subjects

The Ss were 67 children from three schools in the Ann Arbor area, two nursery schools and an elementary school.* All kindergarten and first-grade children from the latter school were tested. All of the nursery school children who were between 4 and 5 years old were tested with the exception of several who refused to participate. Since the distribution of Ss by age did not correspond to their grade level, they were divided after the testing was completed into three age groups containing approximately equal numbers of each sex. Number of Ss, mean age, and age range for each age and sex group are shown in Table 1.

Materials

Four nonsense forms were constructed from freehand drawings. From a number of freehand figures, four were chosen using the following criteria: (a) they were dissimilar to each other; (b) they were amorphous in form, with no straight edges or corners; (c) they were not readily labelable; and (d) the longest axis of the figure was 6 to 9 in. long.

Three variations of each nonsense form were constructed in the following manner. Several points on the circumference of each figure were chosen which, when joined by straight lines, preserved the general form of the figure. The number of these points ranged from six to eight for the four figures. A circle with an approximate diameter of 3/4 in. was

Table 1
Number of Subjects, Mean Age, and Age Range in Each Age and Sex Category of Experiment 1

	Males			Females		
	N	Mean Age[a]	Age Range	N	Mean Age	Age Range
Young	14	4, 8.2	4, 4 to 4, 11	10	4, 8.5	4, 5 to 4, 11
Middle	10	5, 6.3	5, 0 to 6, 1	11	5, 7.7	5, 0 to 6, 2
Old	10	6, 7.8	6, 4 to 6, 11	12	6, 8.3	6, 4 to 7, 0

[a]Ages given in years and months.

drawn around each of these points as center and a random diameter was drawn in each circle. A set of numbers from zero to 360, one for each circle, was chosen from a random number table, and a new radius for each circle was constructed which was different from the original diameter by the number of degrees chosen for that circle. The intersections of each of these radii with their respective circles comprised a new set of points for the figure. These points were then joined by lines which were as similar in contour to the lines in the original figure as possible, creating a new figure similar in general form but not identical to the original.

Using the same circles, but different sets of random numbers, two more alternatives were constructed. A form identical to the original was drawn for the fourth alternative. This process was repeated for each of the four original nonsense forms, generating four sets of stimulus forms, each with four response alternatives, one of which was identical to the stimulus.[1] Each stimulus form with its three variations is shown in Figure 1. It can be seen from Figure 1 that for each stimulus set there are no obvious feature differences between the original stimulus and the incorrect response alternatives. The method of stimulus construction described above was chosen purposely to avoid these feature differences as much as possible. The importance of this design characteristic in the present research is treated more fully in Section IV.

Using these drawings, stimuli and response alternatives were cut from 1/4-in. plywood and painted cherry red. Each stimulus form was mounted on a 14-in. x 14-in. piece of 3/4-in. plywood which was painted flat white. These boards could be locked into a base which held the stimulus in a vertical orientation.

A board 29 in. x 30 in. for the display of the response alternatives was made from 1/4-in. plywood covered with galvanized sheet steel and painted flat white to match the boards on which the stimuli were mounted. Several strips of 1/6-in. magnetized plastic were glued on the back of each response form so that the forms adhered firmly to the display board when it was in a vertical position. This arrangement allowed the response alternatives to be shifted easily between each trial of the experiment. In addition, three silver stars were glued to the back of the response alternative which was identical to the stimulus.

Stimulus Set

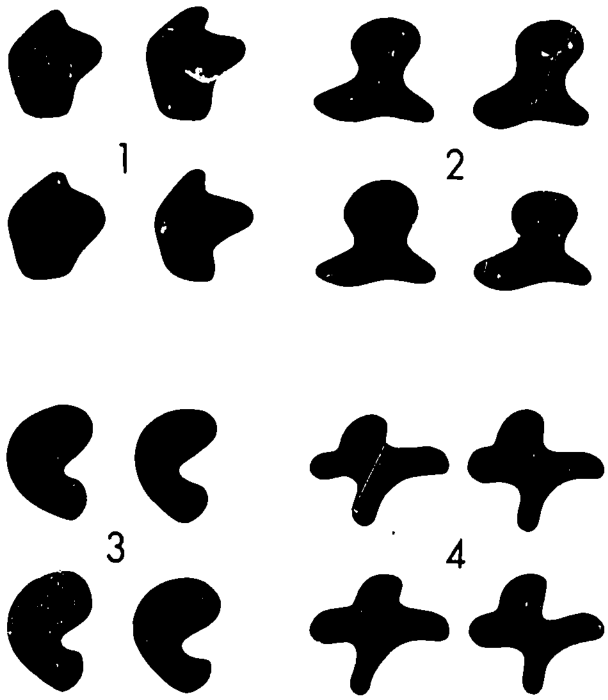

Fig. 1. Response alternatives for each of the four stimuli used in the present research. In each case, the alternative in the upper left-hand corner of the array was identical to the stimulus figure.

Procedure

Approximately half of the Ss in each age-sex subgroup were allowed free haptic exploration during examination of the stimulus figures (Optional Haptic condition). In order to guarantee a comparison group of Ss who used no nonocular motor activity, the remaining half of the Ss were not permitted any tactual contact

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[1] During construction of the stimuli and alternatives a pretest sample of five children between 4 and 5 years old were shown each original form and required to identify it among the four response alternatives. Three of the sets were found to be too easy, since at least three out of five subjects consistently chose the correct alternative. These sets were made more difficult by redrawing the alternatives using circles of smaller diameter at each point.

with the figures (No Haptic condition).

Each S was tested individually either in a quiet room in the school or in a soundproof experimental trailer. The S was seated in a chair, the height of which was adjusted so that the center of the stimulus form was at eye level, and given the following instructions:

> I am going to show you how you can get some M & M candies. Have you ever seen a blob before? [Subject usually said no. The experimenter removed a piece of cardboard covering the first stimulus and exposed it briefly.] That is a blob. I am going to show you this blob for a while. Then I will cover it up again and I will show you four more blobs over here. [The experimenter then removed a piece of cardboard from the display board, briefly exposing the four response alternatives.] I want you to tell me which blob over here looks just like the one you just saw. The one that is the same has stars on the back, so after you choose one we will turn it over and see whether it has stars on it. When you find the one with stars two times in a row, I will give you some M & M candies.

If S was in the No Haptic condition he was also told that he must keep his hands in his lap while he looked at the blob. If S was in the Optional Haptic group, his hands were placed on opposite sides of the stimulus at approximately the horizontal midline so that his fingers touched the edge of the stimulus, and he was told, "You can do anything you want to with your hands."

When E was sure that S understood the instructions, the cardboard covering the stimulus form was removed for 15-20 seconds, timed with a stopwatch.

An attempt was made to equalize the amount of time Ss actually attended to the stimuli by allowing additional time if attention wandered during the exposure interval. When S's eyes were not fixated on the stimulus his attention was returned to it by such remarks as, "Look at the blob very carefully." At the end of the exposure period the stimulus was again covered, and the cardboard covering the response alternatives was removed. After S made his selection the chosen form was turned over so that he could see whether his choice was correct. The form was then replaced on the board and the board was covered.

The S's choice was recorded by means of a code number drawn on the back of the response alternative. In addition, for Optional Haptic Ss an estimate was made by E on each trial of the amount of motor activity produced by S which was in some way correlated with the shape of the stimulus form. This included tracing with one or both hands, and occasionally brushing or rubbing the surface of the stimulus. A rating scale was used which consisted of the integers zero to 3. Zero was assigned if S's hands were stationary throughout the exposure interval, and 3 if his hands were engaged in stimulus-correlated motor activity throughout the entire interval. Ratings 1 and 2 were used to designate intermediate amounts of haptic exploration. These judgments were made before S made his matching response.

It was noticed that several Ss who were not permitted tactual contact with the figures traced the outline of the stimuli with their noses or made exaggerated head movements which obviously reproduced the figures. These movements were recorded also, although no attempt was made to scale their extent. In most cases such movements occupied at least half of the exposure interval.

Each stimulus was exposed repeatedly until S chose the correct response alternative on two consecutive trials. Between each trial the response alternatives were rearranged randomly on the display board. The alternatives always formed a 2 x 2 matrix. In order to discourage position responding after the first trial, S was told that the response alternatives were being rearranged and that he had to look all around for the correct one. No prolonged perseveration on a given response position was observed. After S reached the criterion of two consecutive correct responses he was rewarded with five M & M candies which he could either eat or save. A new set of stimulus and response alternatives was then mounted in place and the procedure was repeated.

As a rule, each S was tested in two sessions, with two stimuli presented per session. However, an attempt was made to adjust the session division to the individual S; if he became severely inattentive or restless, testing was discontinued and resumed on another day.

Three different orders of stimulus presentation were used. Referring to the numbers assigned to the stimulus forms in Figure 1, the three orders were 1-2-3-4, 4-3-2-1, and 3-1-4-2.

Results

Stimulus-Correlated Activity

Averaging over Ss in the Optional Haptic group, the mean activity rating per trial on a zero to 3 scale was 1.07. Analysis of these ratings by age and sex revealed no significant effects of either variable (all Fs < 1).

A frequency distribution of the activity ratings of all Ss in this group is shown in Figure 2. Of the 13 Ss in the lowest activity range (0-.49), nine had scores of zero, and the highest mean rating of the remaining four Ss was only .14. These Ss in the lowest category either held their hands completely immobile on the stimulus figure or else removed them immediately from the figure after their hands were released by E. The remaining 21 Ss (62%) produced varying amounts of stimulus-correlated activity, with a mean rating of 1.8.

The observed activity consisted almost exclusively of one- or two-handed tracing of the perimeter of the figure with one or more fingers extended. When S traced with both hands, usually only one hand was in motion

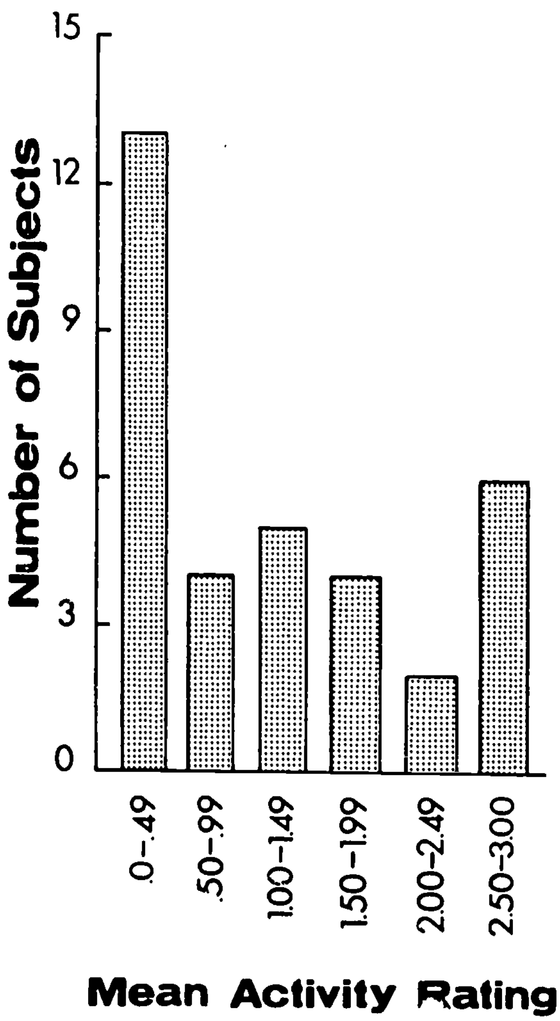

Fig. 2. Frequency distribution of activity ratings in the Optional Haptic group of Experiment 1.

at a time. Simultaneous movements, usually symmetrical, were most commonly observed during examination of Stimulus 2, a nearly symmetrical figure.

Attempts at haptic exploration were made by several Ss in the No Haptic group. When they occurred, S's hands were returned to his lap by E. Six of these Ss, however, made subsequent tracing movements with their heads for the majority of the examination period. These exaggerated head movements followed closely the outline of the stimulus figure.

Activity and Recognition Performance

The effect of stimulus-correlated activity on mean trials to criterion on the recognition task was examined in several analyses. Two conditions, Visual (V) and Visual plus Haptic (V+H), were formed a posteriori on the basis of the actual behavior of Ss in the perceptual task. Originally the V group was to consist of Ss in the Optional Haptic group who did not exhibit haptic activity (mean activity rating < .50) and Ss in the No Haptic group. However, the activity of those Ss in the latter group who traced with their heads was so obviously correlated with the outlines of the stimuli that these Ss were excluded from the V condition. In one analysis, they were included in the V+H condition with Ss who had activity ratings of .50 or greater. In a second analysis they were excluded entirely. Age and sex were also included as factors.

With "head-movers" included, Ss in the V+H condition took fewer trials to reach criterion in the recognition task than Ss in the V condition, $F\ (1,\ 55) = 8.22$, $p < .006$. Performance improved with age, $F\ (2,\ 55) = 13.24$, $p < .001$. The difference between conditions tended to decrease with age, $F\ (2,\ 55) = 2.46$, $p < .09$. Finally, girls tended to reach criterion in fewer trials than boys, $F\ (1,\ 55) = 3.69$, $p < .06$. These data are shown in Figure 3.

These results are essentially unchanged by elimination of the "head-movers" from the analysis. For Conditions, $F\ (1,\ 49) = 5.14$, $p < .028$; for Age, $F\ (2,\ 49) = 10.34$, $p\ .001$; for Age x Conditions, $F\ (2,\ 49) = 2.36$, $p < .10$; and for Sex, $F\ (1,\ 49) = 3.89$, $p < .054$.

An additional analysis was performed using only those Ss in the original Optional Haptic group, comparing those with activity ratings less than .50 (V) and those with ratings of .50 or greater (V+H). Once again, the latter group was superior to the former, $F\ (1,\ 22) = 10.66$, $p < .004$, and performance improved with age, $F\ (2,\ 22) = 3.95$, $p < .03$. No other effects were significant.

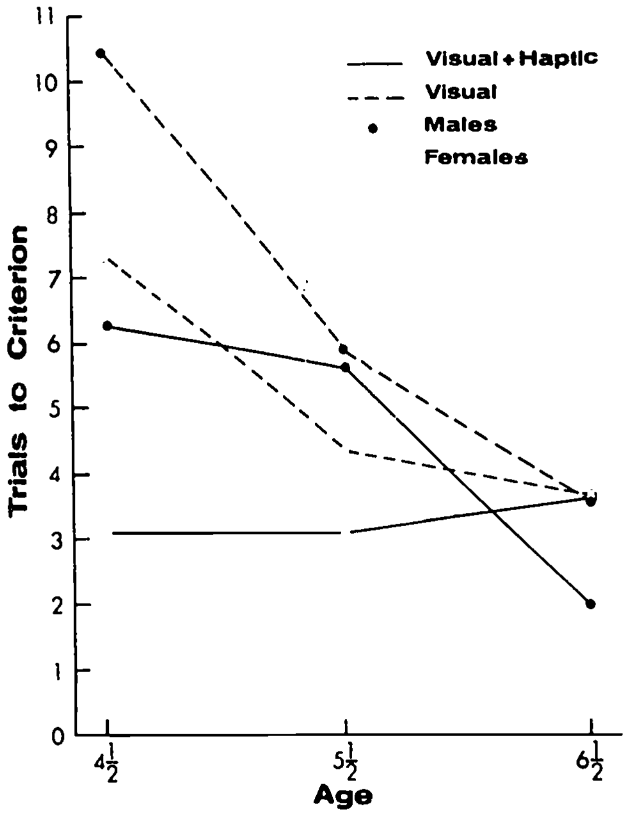

Fig. 3. Mean number of trials to criterion as a function of age, sex, and a posteriori experimental condition (Experiment 1).

Within this group of Ss, the Pearson product-moment correlation between rated activity and mean trials to criterion was computed for each age-sex subgroup. Averaging the six correlations according to McNemar (1962) produced a mean coefficient of −.44, $p < .05$.

Discussion

Two conclusions are invited by the data of the present study. First, children from 4 to 7 years of age when engaged in the perceptual recognition task described above commonly produced what we have termed stimulus-correlated activity. The degree to which tracing activity was a natural response in this task situation may be questionable because of the requirement that Ss touch the edges of the figure at the beginning of each exposure period. Also, the repeated statement, "You can do anything you want with your hands," may have suggested to Ss that some type of movement was desired by E. With regard to the latter point, this statement was repeated several times whether or not S moved his hands. Several Ss began by producing little movement, but gradually increased the amount of movement during the session. However, no S did the reverse—i.e., decreased the extent of his movement during a session. Also, the attempts to trace by several Ss who had received a verbal prohibition against such activity, as well as the tracing head movements of some of these Ss, lend additional force to the argument that the observed tracing was a result of the demands of the perceptual task itself, and not of experimental procedures ancillary to the task.

Second, it can be concluded that the stimulus-correlated movements observed during the task were in some way related to recognition performance, since in several analyses the number of trials to criterion in the recognition task was negatively related to the amount of activity produced by S.

A question of considerable theoretical interest is whether the relationship between activity and perceptual performance changes with age. Most theorists who have addressed themselves to this problem (Hebb, 1961; Piaget & Inhelder, 1956; Zaporozhets, 1965) have assumed that overt activity, ocular or nonocular, becomes unnecessary with increasing age or perceptual experience. Yet very little empirical support for this assumption is available. In the present study no decrease with age in rated activity was found. Averaging over sex, mean ratings were .98, .87, and 1.22 for the 4 1/2, 5 1/2, and 6 1/2 year olds, respectively. Nevertheless, percent facilitation in the V+H condition relative to the V condition does appear to decrease with age.[2] For the data used in the first analysis reported above in which all Ss were assigned to one of the two conditions, these percentages are 89.1, 17.4, and 29.7 for the three age groups, in order of increasing age.

[2]Percentage facilitation was determined by subtracting mean trials to criterion in the V+H condition from that in the V condition, dividing by the former value, and multiplying by 100.

A decline with age in the correlations between activity rating and mean trials to criterion in the recognition task was also found. In order of increasing age, these coefficients are -.72, -.42, and -.18. While these trends are suggestive, further research on this problem is clearly indicated since increasing restriction of range and other factors make their unambiguous interpretation impossible.

Several studies mentioned previously have failed to demonstrate a relationship between overt activity and perceptual performance (Butter and Zung, 1970; DeLeon, Raskin, & Gruen, 1970; Millar, 1971). In all of these studies, haptic activity was imposed a priori on Ss in certain of the experimental conditions, and not determined a posteriori as in the present experiment. A second experiment determined whether the same facilitative effect would be found when using the former procedure.

III
Experiment 2

In the second experiment, three conditions of examination were imposed on separate groups of Ss, using essentially the same perceptual task as in the previous experiment. The Visual (V) condition was the same as that in Experiment 1, in which Ss were not permitted manual contact with the stimulus figures; in the Visual plus Haptic (V+H) condition, Ss were required to examine the stimulus forms haptically during visual inspection; finally, in the Touch (T) condition, Ss were required to touch two edges of the figure with the fingers of both hands, but were restrained from haptic exploration. It was hypothesized that if motor activation is important in the child's perceptual processing, the requirement to touch the stimuli, but remain stationary, might actually inhibit S's visual processing. It was thus predicted that the three conditions would be ordered V+H, V, and T in order of decreasing performance in the recognition task.

Method

Subjects

The Ss were 30 nursery school children, 15 males and 15 females, between 4 and 5 years of age. Ten Ss, five males and five females, were tested in each condition.

Procedure

The tasks and procedures were essentially the same as in Experiment 1, with several modifications. The Ss in all conditions were initially trained in haptic exploration in a separate session using an oval shaped figure, mounted in the same way as the other stimuli, but painted brown. Each test figure was then presented in a separate session in order to insure a minimum of fatigue and boredom. Thus, each S was tested in five sessions, separated by one to five days. All Ss were presented the stimulus figures in the same order, 1, 2, 3, and 4. After each session, S was permitted to choose a trinket or balloon to keep. No other reward was given.

In order to equate the amount of experience each S received in the perceptual task, S was given 12 trials on each figure, rather than using a criterion as in the first experiment. Analyses are based on the number of correct responses on the 12 trials.

Results and Discussion

Mean number of correct recognition responses for the T, V, and V+H conditions was 3.38, 3.75, and 5.32, respectively, $F\ (2, 24) = 5.07$, $p < .015$. These means are in the predicted order. However, paired comparisons showed that while the T and V conditions differed from the V+H condition ($p < .05$) they did not differ significantly from each other. No significant effects of sex or stimulus set were found. Chance performance is three correct responses assuming random selection among the four alternatives. All conditions except T significantly exceeded this chance value ($p < .05$).

IV
General Discussion

Haptic examination facilitated visual recognition in these experiments, contrary to the findings of several previous studies cited above which used similar tasks and subject populations. Two major differences between these studies and the present ones may be important in explaining the apparently discrepant results we obtained. First, a deliberate attempt was made through the method of construction to create amorphous stimulus figures, and response alternatives which differed from the stimuli in general configuration, but not in perceptually obvious features. There is some evidence that an analytic feature detection approach to perceptual tasks develops with age (Elkind, Koegler, & Go, 1964; Kagan, Moss, & Sigel, 1963). It is also probable that some stimuli are more easily discriminable on the basis of isolated, perhaps symbolically represented, parts than others, and that children can apply this perceptual-cognitive style earlier to these stimuli than to less analyzable stimulus sets. Examination of the stimuli used in the studies cited above suggests that they were more analyzable in this sense than those used in the present research. This difference in stimulus materials could be important for the different results obtained if overt motor activity is more closely related to the construction of Gestalt-like percepts than to the detection of differences between values on feature dimensions which are already familiar to the child.

Second, all of the previous studies have used a single presentation, single test method. If motor activity is related in some way to the construction of the child's percept (Neisser, 1967; Zaporozhets, 1965), a repeated trials procedure may be more sensitive to the process of gradual construction than a single trial procedure. The data of Experiment 2 support this hypothesis. In separate analyses of the first and last six trials of each condition, a significant Condition effect was found for the last six trials, $\underline{F}\ (2,\ 24) = 5.13$, $\underline{p} < .025$, but not for the first six, $\underline{F}\ (2,\ 24) = 2.82$, $\underline{p} > .05$.

A major theoretical concern is the role which overt activity plays in the perceptual processes of the child. While no definitive solution to this problem can be given from the results of these experiments, we can draw some tentative conclusions. First, on a priori grounds the Russian argument that feedback from overt activity generated in response to the external stimulus constitutes the percept is an unlikely explanation, since it fails to account for adult perceptual experience which apparently can occur in the absence of overt activity.

Secondly, the data from the head-movers in Experiment 1 suggest that the facilitative effect of stimulus-correlated activity is not due alone to a coupling of eye with hand movements. Head-movers occurred in five of the six age-sex subgroups in the No Haptic group. In each of these subgroups the head-movers reached criterion in fewer trials than the best of the remaining Ss in that subgroup. Thus, while in these cases S's eyes could not be following a moving extremity, this stimulus-correlated activity seemed to be associated with enhanced recognition performance.

Festinger and his coworkers (Festinger & Canon, 1965; Festinger, Ono, Burnham, & Bamber, 1967) have hypothesized that efference, or motor outflow, rather than feedback is the sine qua non of perceptual experience. When, with age or prior exposure of a particular configuration, perception becomes "internalized," a motor plan, conceived but not executed, serves the perceptual function. Young children, on the other hand, do not inhibit the execution of these plans, and therefore they are realized in overt activity. If the important contribution to perceptual experience is the motor plan itself, then the part of the organism which executes the actual movement may be irrelevant. Supporting this notion, Festinger et al. (1967) found visual adaptation to prism-induced curvature after Ss produced stimulus-correlated movements with either their eyes or their hands.

Considered in this manner, the hand or head activity observed in these experiments is not directly causal with respect to the perceptual experience. Rather, it is correlated with it in the sense that it demonstrates that a motor plan, which is directly related to that experience, has been generated. We have offered a similar theoretical explanation of children's generation of mental imagery (Wolff & Levin, in press; Wolff, Levin, & Longobardi, in press), and are currently examining its applicability to early language production.

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